AD-A067 241 NAVAL WEAPONS SUPPORT CENTER CRANE IND F/G 6/3

SELF DIFFUSION IN CELLS AND TISSUES.(U)

JAN 79 J E TANNER

UNCLASSIFIED NWSC/CR/RDTR-101 NL

1 OF 1

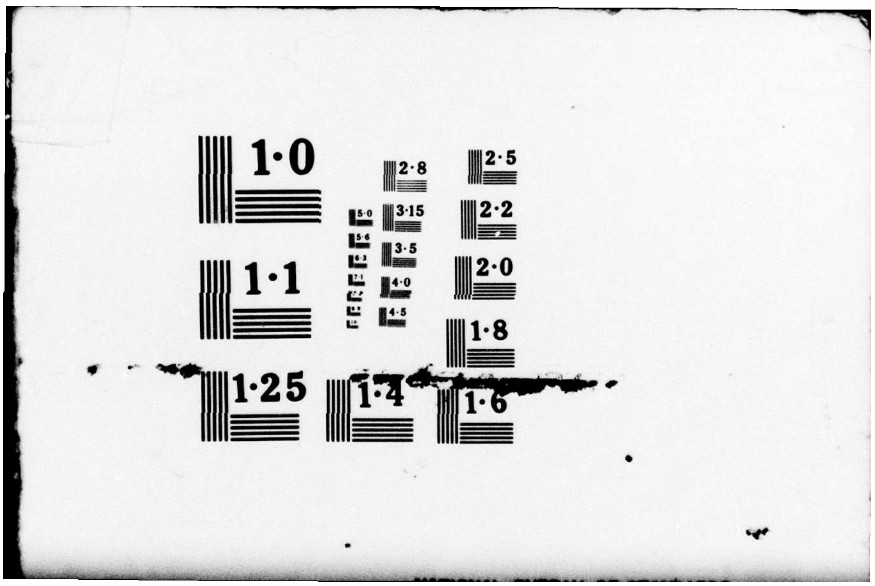
ADA 067241

END

DATE FILMED

6-79

DDC


1·0
2·8
2·5
3·15
2·2
5·0
5·6
3·5
1·1
2·0
4·0
4·5
1·8
1·25
1·4
1·6

LEVEL II

UNCLASSIFIED

13
Na

NWSC/CR/RDTR-101

SELF DIFFUSION IN CELLS AND TISSUES
ANNUAL REPORT NO. 4

AD A0 67241

by
John E. Tanner, Jr.

Naval Weapons Support Center
Applied Sciences Department
Crane, IN 47522

1 January 1979

Final Report for Period 1 October 1977 to 31 December 1978

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

Prepared for:
Office of Naval Research
Medical and Dental Science
Arlington, VA 22217

79 04 09 118

Submitted

B. E. DOUDA
Manager, Chemical Sciences Branch
Pyrotechnic Division
Applied Sciences Department

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
14 NWSC/CR/RDTR-101

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
6 Self Diffusion in Cells and Tissues.
Annual Report No. 4

5. TYPE OF REPORT & PERIOD COVERED
9 Annual rept. no. 4,
1 Oct [redacted]77 - 31 Dec [redacted]78,

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
10 John E. Tanner, Jr

8. CONTRACT OR GRANT NUMBER(s)
N0001479WR90035

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Naval Weapons Support Center
Applied Sciences Department
Crane, Indiana 47522

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
17 RR041-08-02
207-013
61153 N

11. CONTROLLING OFFICE NAME AND ADDRESS
Office of Naval Research
Medical and Dental Science
Arlington, Virginia 22217

16 RR04108

12. REPORT DATE
11 1 Jan[redacted]79

13. NUMBER OF PAGES
8

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)
12 9p.

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)
Approved for Public Release: Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES
Reproduction in whole or in part is permitted for any purpose of the United States Government.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Biophysics
Diffusion
Nuclear Magnetic Resonance
Heat Flow

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
A general treatment of time-dependent (transient) diffusion coefficients in a system of parallel planar barriers of arbitrary permeability has been published in J. Chem. Phys. 69, 1748 (1978). Measurements of self diffusion of water and of membrane permeability to water in red blood cells, frog muscle, E. coli and a literature review of previous measurements have been submitted for publication to Biophysical Journal.

79 04 09 118

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601

UNCLASSIFIED 409 351

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

BACKGROUND AND PROGRESS

Magnetic field gradient NMR is well adapted to measuring diffusion in colloidal systems, including biological cells, because the experimental measurement times by this method are such that the distances traveled by the molecules are of the same order as the dimensions of the inhomogeneities of the system. The result is that the apparent diffusion coefficients are dependent on the diffusion time. By varying this latter parameter the dimensions of the inhomogeneities as well as the local diffusion coefficients within them can be obtained.

The maximum information is obtained by the use of the widest possible range of diffusion times. In previously reported work,[1,2] a variety of recently developed techniques have been used to get a much wider range of diffusion times than had been employed in earlier studies of diffusion in biological materials. Intracellular diffusion coefficients have been measured in human red cells, three types of frog muscle, E. coli and yeast cells. It was also possible to estimate the cell membrane permeability in the first two cases.

This work has been presented at several national scientific society meetings. It has since been written up and has recently been submitted to the Biophysical Journal under the title, "Intracellular Diffusion of Water; Measurements and Review". The review implied by the title covered all measurements of diffusion coefficients of water in cells by magnetic field gradient methods (pulsed or cw) up to 1977. The reported measurements cover over a dozen types of plant and animal tissues and single cell types. The values extend to as low as 1/5 the value of pure water, in contrast to some ESR measurements of free radical line widths, which

imply much lower diffusion rates.[3] Additional details and discussion are contained in a report presented earlier in the year.[4]

The experimental data for diffusion measurements in cellular systems usually consists of apparent diffusion coefficients over a range of diffusion times. In order to extract the intracellular diffusion coefficient and the barrier separation and permeability from this data it is necessary to know the functional form of the dependence of apparent diffusion coefficient on diffusion time for the geometry under consideration (or for a similar one). Most cells have highly permeable membranes. However there had not been in the literature a derivation of transient diffusion in a viscous medium for any geometry involving permeable barriers. Therefore a derivation was performed for the case of parallel planar geometry. The essentials of the results are contained in a previous report,[5] and were presented as poster W-POS-K2 at the March 1978 joint meeting of the Biophysical Society and the American Physical Society in Washington D. C. A complete report has been written and has appeared in J. Chem. Phys. 69, 1748 (1978), entitled "Transient Diffusion in a System Partitioned by Permeable Barriers. Application to NMR Measurements with a Pulsed Field Gradient".

The parallel plane case in one dimension is identical to the case of a cubical array in three dimensions, and is probably a good first approximation to the general case of spheres packed into polyhedra. Therefore, the results of this derivation should be valuable for interpreting NMR diffusion data on many biological smaples of tissues or pellets of centrifuged single cells. The parameters obtained by applying this theory to the experimental systems mentioned earlier seemed reasonable, and were in agreement with such literature values

as existed.

PLANS FOR FUTURE WORK

Minor modifications have been made to the pulsed gradient apparatus for greater reliability and ease of operation. A wide variety of cell types furnished by faculty of the Chemistry and Biology Departments of Indiana University are scheduled for measurements due to take place in March. Included are attempts to measure intracellular diffusion of substances other than water.

I have accepted an invitation to collaborate with Professor R. Kosfeld of the Technical University of Aachen on a review paper on the use of NMR to study diffusion.

REFERENCES

1. TANNER, J. E., Self Diffusion in Cells and Tissues, NWSC/CR/RDTR-6, Naval Weapons Support Center, Crane, IN (June 1975). Available Defense Documentation Center (DDC), Cameron Station, Alexandria, VA 22314. AD-A014601.

2. TANNER, J. E., Self Diffusion in Cells and Tissues, NWSC/CR/RDTR-42, Naval WEapons Support Center, Crane, IN (October 1976). DDC AD-A031257.

3. KEITH, A. D. and SNIPES, W., Science 18, 666 (1974).

4. TANNER, J. E., Self Diffusion in Cells and Tissues, Work Assignment summary of 15 July 1978, by Naval Weapons Support Center, Crane, IN on project number RR041-08-02 for the Office of Naval Research (444) Arlington, VA 22217.

5. TANNER, J. E., Self Diffusion in Cells and Tissues, NWSC/CR/RDTR-73 Naval Weapons Support Center, Crane, IN (October 1977). DDC AD-A053422.

DISTRIBUTION LIST

ADDRESS	COPIES
Administrator, Defense Documentation Center Cameron Station Alexandria, Virginia 22314	12
Director, Naval Research Laboratory Attention: Technical Information Division Code 2027 Washington, D. C. 20390	6
Director, Naval Research Laboratory Attention: Library Code 2029 (ONRL) Washington, D. C. 20390	6
Office of Naval Research Medicine and Dentistry Code 444 Arlington, Virginia 22217	3
Director, Research Division Bureau of Medicine and Surgery Department of the Navy Washington, D. C. 20390	2
Technical Reference Library Naval Medical Research Institute National Naval Medical Center Bethesda, Maryland 20014	2
Office of Naval Research Branch Office 495 Summer Street Boston, Massachusetts 02100	1
Office of Naval Research Branch Office 536 South Clark Street Chicago, Illinois 60605	1
Office of Naval Research Branch Office 1030 East Green Street Pasadena, California 91101	1
Office of Naval Research Contract Administrator for Southeastern Area 2110 G. Street, N. W. Washington, D. C. 20007	1

DISTRIBUTION LIST (cont.)

ADDRESS	COPIES
Commanding Officer U. S. Naval Medical Research Unit No. 2 Box 14 APO San Francisco 96263	1
Commanding Officer U. S. Naval Medical Research Unit No. 3 FPO New York 09527	1
Officer in Charge U. S. Naval Medical Research Unit No. 4 U. S. Naval Hospital Great Lakes, Illinois 60088	1
Commanding Officer Naval Submarine Medical Research Laboratory Naval Submarine Base, New London Groton, Connecticut 06340	1
Scientific Library U. S. Naval Medical Field Research Laboratory Camp Lejeune, North Carolina 28542	1
Scientific Library Naval Aerospace Medical Research Institute Naval Aerospace Medical Center Pensacola, Florida 32512	1
Commanding Officer Naval Air Development Center Attention: Aerospace Medical Research Department Johnsville, Warminster, Pennsylvania 18974	1
Scientific Library Naval Biomedical Research Laboratory Naval Supply Center Oakland, California 94625	1
Director, Life Sciences Division Army Research Office 3045 Columbia Pike Arlington, Virginia 22204	1
Director, Life Sciences Division Air Force Office of Scientific Research 1400 Wilson Boulevard Arlington, Virginia 22209	1

DISTRIBUTION LIST (cont.)

ADDRESS	COPIES
Commanding General U. S. Army Medical Research & Development Command Forrestal Building Washington, D. C. 20314	1
Commander Naval Air Systems Command Department of the Navy Washington, D. C. 20361 Attention: Code AIR-954, Technical Library	2
Code AIR-310C, Dr. H. Rosenwasser	1
Commander Naval Sea Systems Command Naval Sea Systems Command Headquarters Washington, D. C. 20362 Attention: Code SEA-09G3, Technical Library	2
Commander Naval Weapons Center China Lake, California 93555 Attention: Code 533, Technical Library	2
Commander Air Force Avionics Laboratory Wright-Patterson Air Force Base Ohio 45433 Attention: Code AFAL/CC	1